Consultative Committee for Space Data Systems

REPORT CONCERNING SPACE DATA SYSTEM STANDARDS

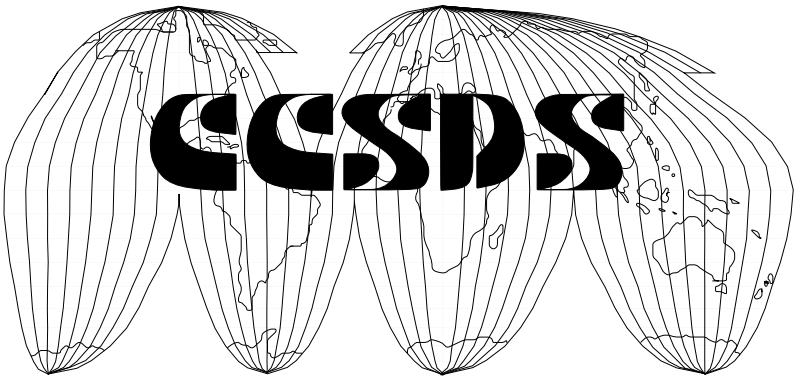
CCSDS CROSS SUPPORT SYSTEM DESCRIPTION VOLUME 1

CROSS SUPPORT CONCEPT
AND
SYSTEM SCENARIOS

CCSDS 910.1-G-1

GREEN BOOK

June 1990



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FOREWORD

The Consultative Committee for Space Data Systems (CCSDS) is an international organization officially established by the management of multiple space agencies. Its charter is to facilitate interoperability between space agencies through the development of data handling techniques for spacecraft operations, space research and space science applications.

To realize the maximum benefit, agencies voluntarily implement internal standards consistent with CCSDS recommendations. This allows increased mission benefits from a growing capability to provide inter-agency cross support. Specific instances of cross support for a particular mission will be based on multi-agency agreements specific to that mission.

The ensuing capabilities for providing cross support and sharing ground- and space-based facilities on an international basis will enable greater flexibility in individual agency mission planning and will facilitate integration of international payloads and missions.

CCSDS Recommendations are intended to complement, not compete with, other international standards. Other international standards are utilized where applicable, while CCSDS activities are focused on system aspects unique to space data systems.

This document is an informational report (Green Book). It provides a high level description of CCSDS cross support and expands on the concepts contained in the Introduction to CCSDS Cross Support Green Book.

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1 INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the Consultative Committee for Space Data Systems (CCSDS) cross support concept. It is a CCSDS informational report (Green Book).

1.2 Scope

This document presents the Cross Support Concept for CCSDS. The concept applies to all Space Data Systems developed by participating CCSDS Space Agencies but is focused on those missions which will involve cross support between multiple Space Agencies. This document is intended to be a high level "user's guide" and as such is produced from the user's perspective. It presents a logical high level model of the Space Data System which allows appropriate cross support capabilities.

Volume 2 of the document title provides an identification of the cross supported services covered by CCSDS. Volume 3 presents the system management aspects of the space data system.

1.3 Methodology

The CCSDS Cross Support concept, reflected in this document, is developed according to a general methodology. The following paragraphs describe the steps in the process

First, a broad range of scenarios for conventional missions, Advanced Orbiting Systems (AOS), and post-mission information interchange are developed. These scenarios identify services potentially available to users and introduce the notion of CCSDS cross support. These scenarios provide an informal means of "validating" the CCSDS cross support concept.

Next, a space data system model is developed, from the point of view of a single generic space agency. By replicating the model, it is used to show the use of one agency's resources and services by another agency.

The space data system model is then augmented to include the points at which User Agencies may access the resources and services made available to them by Provider Agencies.

Cross Support cannot be achieved without the interaction of the appropriate User and Provider Agency management entities. The actual agency resources provide only the "ability" to cross support - the management entities provide the "availability" of the resources. Therefore, a User/Provider Agency model is developed in which entities are identified and defined providing interfaces between User and Provider Agency management entities.

Finally, the Space Data System Model and the User/Provider Agency model are integrated to produce an overall model for CCSDS cross support.

1.4 Organization of Document

Section 1 presents an introduction to this document. Section 2 contains the descriptions of the scenarios of typical space data systems. The scenarios are used to identify services potentially available to users. Then Section 3 presents a generic space data system model for a generic space agency. It also relates each of the scenarios to the model. Section 4 introduces the CCSDS cross support concept. It derives the management entities and interfaces required to facilitate cross support. It also presents the CCSDS concept of services. Section 5 presents an overall CCSDS cross support model and expands the scenarios presented in Section 3 to include typical management interactions. Section 6 presents the hierarchy of CCSDS recommendations and reports that define CCSDS services in terms of their functionality.

2 SCENARIOS

This section presents a wide range of high-level space data system scenarios for conventional missions, advanced orbiting systems, and post-mission information interchange. These scenarios are presented from the user's perspective and from an operational point of view. They describe situations where a P Agency (Provider Agency) supports a U Agency (User Agency). The provider is associated with a CCSDS member agency space data system. The user is either associated with another member agency space data system or sponsored by a member agency. Each agency identifies the specific resources and services that it provides or requires according to its specific technical objectives, and mission requirements. Descriptions of the services identified in the scenarios are presented in more detail in CCSDS documents referred to in Section 6.

Each of the scenarios described in this section contains the following:

- An "Example" paragraph providing examples to illustrate the scenario.
- A "Definition" paragraph defining the agencies involved in the scenario.
- A "Description" paragraph presenting a generalized description of the scenario.
- A "Responsibilities" paragraph providing an overall definition of the responsibilities of the P and U Agencies.
- A "Data Exchange" paragraph describing the data/information exchanged between the P and U Agencies. The medium for data/information exchange is not defined.
- A "Services" paragraph identifying the services that support the scenario.

Scenarios presented in this section describe events and interactions that can be used to expose, define, validate, and test CCSDS management and technical concepts, and operational procedures. These scenarios also aid in identifying, developing, and validating CCSDS services, and provide the basis for developing CCSDS cross support models, which are presented in Sections 4 and 5.

Figure 2-1 provides a summary of the ten scenarios included in this section.

CCSDS SYSTEM SCENARIO	FLIGHT/ MISSION	SPACE AGENCIES INVOLVED	CROSS SUPPORT PROVIDED
1. Launch	ARIANE	NASA INPE CNES	Launch Vehicle Tracking, Trajectory
2. Bit Stream	SPOT1	NASDA CNES	RF and Modulation, and Tracking (at the Bitstream level)
3. TT&C Network	AMPTE	NASA DLR	Tracking, Telemetry, and Control Network
4. Spacecraft Monitor and Control	GALILEO	DLR NASA	Spacecraft Monitor and Control
5. Single Spacecraft, Multi-Agency Instruments	TOPEX	NASA CNES	Multiple Project Operations Control Centers
6. Multi-Spacecraft, Multi-Agency	ISTP	NASA ESA ISAS	Multiple Spacecraft Monitor and Control (for multiple Space Agencies)
7. Telescience	SSF	NASA ESA	Real-time instrument Control (from ground)
8. Teleanalysis	none identified	none identified	Data Base Management and Maintenance, Catalog and Directory services
9. Ground Internetworking	MOS	CNES NASDA ESA	Ground Networks, Gateway Services
10. Videoconferencing	SSF	NASA ESA	2-Way Real-time Audio and Video

Figure 2-1 CCSDS Cross Support System Scenarios

2.1 Scenario 1 - Launch Support

2.1.1 Example

During the ARIANE launch, launch vehicle tracking support is provided by the NASA Ascension Island tracking station.

2.1.2 Definitions

P Agency - Agency providing the tracking support (NASA)

U Agency - Agency launching the spacecraft (CNES)

2.1.3 Description

The P Agency provides launch vehicle tracking support to the U Agency. This support generally involves trajectory support (including radars) and launch vehicle telemetry support.

The trajectory support may be extended to the tracking of remaining parts of the launch vehicle after satellite injection in order to detect a potential collision with the injected payload.

2.1.4 Responsibilities

Prior to the launch, the compatibility between the spacecraft and the P Agency Ground Station must be confirmed via a test procedure (not required for radar support).

2.1.5 Data Exchange

The U Agency provides preflight trajectory estimates. During the flight, the P Agency provides trajectory measurements and, optionally, launch vehicle telemetry. The telemetry may be preprocessed in order to transmit in real-time a limited set of parameters (e.g., inertial data) for "quick-look" purposes. In addition, this telemetry is stored and provided to the U Agency after the launch.

2.1.6 Services

- Trajectory measurement
- Raw launch vehicle telemetry
- Processed launch vehicle telemetry

2.2 Scenario 2 - Bit Stream Support

2.2.1 Example

During the SPOT1 launch, NASDA provided to CNES the support of the Katsurra ground station. CNES equipment was installed in the NASDA ground station and connected to the Toulouse Space Center using the CNES data exchange protocol. Only one NASDA ground station was requested.

2.2.2 Definitions

P Agency - Agency providing ground satellite link support (NASDA)

U Agency - Agency owning the satellite (CNES)

2.2.3 Description

The P Agency provides radio frequency (RF) and modulation, and tracking support to the U Agency. The support is limited to one ground access point. The interface is at the bit stream level. The U Agency equipment may be installed in the P Agency ground station.

2.2.4 Responsibilities

The supporting P Agency is responsible for the control and monitoring of its ground station equipment, from the antennas to the ground interface. The equipment is configured according to the configuration specified by the U Agency and to a mission sequence of events. The U Agency equipment may be operated either by U Agency staff or by P Agency staff.

2.2.5 Data Exchange

The spacecraft trajectory predicts, which are used by the P Agency to drive the antennas, are produced either by the U Agency or directly by the P Agency. Due to launch delay, the predicts may have to be updated a short time before the actual support.

The following information are exchanged during the support :

- Telemetry bit stream (Pulse Code Modulation)
- Telecommand bit stream (Pulse Code Modulation)

2.2.6 Services

- Telemetry (at the bit level / Pulse Code Modulation)
- Telecommand (at the bit level / Pulse Code Modulation)
- RF tracking and acquisition
- Antenna positioning

2.3 Scenario 3 - TT&C Network Support

2.3.1 Example

For the duration of the Active Magnetic Particle Tracer Experiment (AMPTE), which was a cooperative scientific mission, NASA provided DLR with Tracking, Telemetry, and Control (TT&C) network support on a routine basis.

NASA has provided TT&C network support during satellite launch and early orbit phases to various space agencies in support of numerous missions (e.g., DLR - Helios and Symphonie).

2.3.2 Definitions

P Agency - Agency providing the TT&C network support (NASA)

U Agency - Agency operating the satellite (DLR)

2.3.3 Description

The P Agency provides RF receiving and transmission links to the U Agency spacecraft using one or several ground stations.

2.3.4 Responsibilities

The supporting P Agency is responsible for the control and monitoring of the various elements of the TT&C network, from the antennas to the ground interface. The TT&C network is set up according to the configuration specified by the U Agency and according to the mission sequence of events.

2.3.5 Data Exchange

The spacecraft trajectory predicts, which are used by the P Agency to drive the antennas, are produced either by the U Agency or directly by the P Agency. The following data can be exchanged during the support :

Telemetry - During the support, the P Agency provides the received telemetry to the U Agency in real-time. The lowest level of service is the delivery of bits. A higher level of service is the delivery of structured data units (e.g., telemetry frames, telemetry packets) to the U Agency. The P Agency may be requested to store the received telemetry with the time of reception and to replay it upon request. The transport protocol used is agreed on by both agencies.

Telecommand: The P Agency receives telecommand data units from the U Agency and transmits them to the U Agency spacecraft at the prescribed time.

Radio metric data: Radio metric data, including angle data, are measured on request or according to the mission sequence of events. The data may be transmitted by the P Agency in real-time or non real-time.

Ground monitoring: The status of the elements of the TT&C network is reported by the P Agency to the U Agency.

Operational coordination: Operational coordination is accomplished by operational messages or by voice.

2.3.6 Services

- Telemetry (transfer frames, virtual channels, packets)
- Telemetry store and playback
- Telecommand (transfer frames, virtual channels, packets)
- Telecommand store and forward
- Radio Metric
- Ground system monitoring
- RF tracking and acquisition
- Antenna positioning
- Time

2.4 Scenario 4 - Spacecraft Monitor and Control Support

2.4.1 Example

During the cruise phase (i.e., beginning 2 years after launch and lasting for approximately 3 years) of the Galileo mission, DLR will monitor and control the Galileo spacecraft and will report any anomalies to the user agency, i.e., NASA. In addition, DLR will provide Master Data Records to NASA in the form of tapes. They will include all relevant ancillary data.

2.4.2 Definition

P Agency - Agency providing a back-up control center (DLR)

U Agency - Agency owning the satellite (NASA)

2.4.3 Description.

The P Agency provides a back-up spacecraft control center to the U Agency. The tracking support may be provided by the P Agency or the U Agency or a third Agency.

2.4.4 Responsibilities.

The P Agency provides spacecraft monitoring and control according to the U Agency-provided procedures. The P Agency provides a record of events detected and actions taken, and telemetry data, if requested. The U Agency provides the P Agency with the monitoring characteristics of the instrument (e.g., configuration, engineering unit conversion, alarm limits, monitoring rules). In the more general case, the P Agency is authorized to send a predetermined limited set of commands.

2.4.5 Data Exchange

The U Agency provides the support initiation request. The P Agency provides the U Agency with the status of the spacecraft, the results of telemetry and navigation processing, and a record of the control actions taken.

2.4.6 Services

- Spacecraft monitoring and control

2.5 Scenario 5 - Single Spacecraft, Multi-Agency Instruments Support

2.5.1 Example

TOPEX/POSEIDON is a joint project between NASA and CNES. The satellite will be provided by NASA and will be launched on ARIANE. The project operation control center will be at the Jet Propulsion Laboratory (JPL) and will control the spacecraft and process the data from NASA instruments. The data from CNES instruments will be sent for processing to the DORIS/POSEIDON Control Center at Toulouse.

2.5.2 Definitions

P Agency - Agency providing the spacecraft (NASA)

U Agency - Agency(ies) providing one or more instruments (CNES)

2.5.3 Description

This scenario corresponds to the case where instrument(s) from one or more U Agency(ies) are flown on a P Agency spacecraft.

2.5.4 Responsibilities

The P Agency controls the spacecraft, receives the telemetry, and extracts the data for the U Agency instrument(s).

The P Agency is responsible for the definition, and the monitoring and control of the interface between the U Agency instrument(s) and the spacecraft. The real-time monitoring of the U Agency instrument(s) may be the responsibility of the P Agency spacecraft control center. In that case, the U Agency must provide the P Agency with the monitoring characteristics of the instrument(s) (e.g., configuration, engineering unit conversions, alarm limits, monitoring rules).

The P Agency controls the spacecraft resources.

2.5.5 Data Exchange

The U Agency instrument provides telemetry to and accepts instrument commands from the P Agency spacecraft interface.

If the U Agency instrument(s) have to be commanded, the U Agency provides to the P Agency the set of command data to be sent to the instrument(s). The P Agency merges these commands with other command data and sends it to the spacecraft at the appropriate time.

The P Agency provides to the U Agency the instrument telemetry and the ancillary data that are required by the U Agency.

2.5.6 Services

- Spacecraft monitoring and control
- Data extraction
- Ancillary data
- Spacecraft management
- Telemetry (transfer frames, virtual channels, packets)
- Telemetry store and playback
- Telecommand (transfer frames, virtual channels, packets)
- Telecommand store and forward
- Radio metric
- Ground system monitoring
- RF tracking and acquisition
- Antenna positioning
- Telemetry and telecommand on-board data handling

2.6 Scenario 6 - Multi-Spacecraft, Multi-Agency Support

2.6.1 Example

The International Solar Terrestrial Physics (ISTP) Program/Collaborative Solar Terrestrial Research (COSTR) Initiative provides for the development and operation of instruments on the ESA's Solar Terrestrial Science Programme (STSP) spacecraft, along with associated ground system operation and data analysis support. NASA support elements include the NASA Communications Network (NASCOM), JPL, the Deep Space Network (DSN)/Ground Communications Facility (GCF) operated by JPL, and the Goddard Space Flight Center (GSFC).

ESA is responsible for overall management of the mission. NASA/GSFC is responsible for implementing the operational phase of the SOHO mission and providing the facilities required to accomplish science data acquisition and mission analysis, and spacecraft tracking and control. NASA/JPL is responsible for management and operation of the DSN stations providing tracking, telemetry, and command support.

Instrument data processing will be accomplished in the ISTP-dedicated Central Data Handling Facility (CDHF) located at GSFC from telemetry data received by the DSN. Data analysis and theoretical studies will be conducted by members of the ISTP science teams from the Remote Data Analysis Facilities. Flight operations will be performed with mission support systems at GSFC, with real-time control originated by members of the ISTP science team.

All source packets are based on a standard source packet format consistent with CCSDS standards for packet telemetry. The housekeeping data will be routed via GCF and NASCOM to the appropriate Project Operations Control Center whose task will be to monitor and control the spacecraft. The science data will be sent to the dedicated ISTP CDHF for further processing and distribution to the investigators via the remote facilities.

2.6.2 Definition

P1 Agency - Provider of one or more spacecraft carrying instruments (payloads) developed by both P1 and P2 agencies (ESA, NASA)

P2 Agency - Provider and operator of facilities for mission support from ground including tracking and navigation, data processing and archiving (NASA)

U Agency - Provider of on-board instruments operation, science data processing and interpretation and distribution to end users of mission products (NASA, ESA)

2.6.3 Description

This scenario corresponds to the case where P1 Agency and P2 Agency instruments are flown on two or more P1 Agency spacecraft. The P2 Agency receives downlink data from P1 Agency spacecraft, provides the ground data system and all supporting services, and transmits processed telemetry and ancillary data to the U Agency data handling facility.

2.6.4 Responsibilities

The P1 Agency is responsible for the overall management of the mission. The P2 Agency is responsible for implementing the operational phase of the mission and for providing the facilities required to accomplish science data acquisition, ground communications and spacecraft tracking and control including orbit determination and control. The P2 Agency is also responsible for management and operation of the stations providing tracking, telemetry and command support, and of the interfaces and ground communications between its own facilities and the facilities of the U Agency.

The U Agency is responsible for providing the facilities required for the operation of the scientific payloads on-board the spacecraft(s), and interpretation of scientific products from the telemetry and ancillary data received from the P2 Agency and finally distribution of the scientific products to the end users.

2.6.5 Data Exchange

The following presents typical ground/space and ground/ground data exchange between the P1, P2, and U Agencies:

Ground / Space data exchange:

P1 Agency to P2 Agency - Telemetry data, radio metric data

P2 Agency to P1 Agency - Commands, radio metric data

Ground / Ground data exchange:

P2 Agency to U Agency - Calibrated or uncalibrated science telemetry and related ancillary data or archived data and related ancillary data.

U Agency to P2 Agency - Integrated schedule requests, command schedules.

2.6.6 Services

- Spacecraft monitoring and control
- Data extraction
- Ancillary data
- Spacecraft management
- Real-Time Telemetry
- Off-line Telemetry
- Real-time command
- Off-line command (store and forward)
- RF tracking and acquisition
- Telemetry and Telecommand on-board data handling
- Radio metric, Orbit determination and control
- Orbit control
- Network management

2.7 Scenario 7 - Telescience Support

2.7.1 Example

"Telescience" is the name given to the process by which scientific or other end users on the ground may interact with their instruments on-board a spacecraft in "real-time". In this context, "real-time" is a period which is short enough to allow a user to respond to events on-board in a timely fashion (a round trip delay of up to 10 seconds is a typical figure quoted for space station operations).

A telescience end user will typically be a scientist associated with one Agency who is operating a facility on-board another Agency's spacecraft. In this case, ESA uses the facilities on the NASA module of Space Station Freedom.

The telescience user will require both an uplink for commands and a downlink for housekeeping telemetry and science data. The operational regime required for effective telescience is one of minimal interference and delay of both the uplink and downlink. It is therefore necessary for a telescience session to be planned in advance so that a minimum of command checking is performed between the command being issued by the user and being received by the instrument.

2.7.2 Definitions

P Agency - Agency providing access to the user's instrument in space (NASA)

U Agency - Agency through which the end user (e.g., scientist) obtains services (ESA)

2.7.3 Description.

An end user, attached to one Agency, interacts in "real-time" with one or more instruments on-board a facility in space. The scenario may be extended to a set of end users interacting with a set of instruments in space.

It should not make a difference to the user(s) whether the support is provided by one Agency or by several Agencies. The user should feel directly on-line to the instrument whatever the routing of commands and data.

2.7.4 Responsibilities

The Agency providing the end user access point is responsible for the management of the access point .

Each of the Agencies providing support manage the planning, scheduling, monitoring and control of the resources they are providing.

When a P Agency provides simultaneous support for several users from one or more U Agency, the P Agency manages the priority between the users as well as conflict resolution, according to a plan already agreed between the users. This can apply to the Agency providing tracking network support and to the Agency responsible for the spacecraft.

2.7.5 Data Exchange

The end user is provided with unprocessed housekeeping and/or science data from his instrument.

Commands from the end user are transmitted to the instrument with minimal interference, provided pre-arranged resource limits and access criteria are observed.

2.7.6 Services

- Telemetry (transfer frames, virtual channels, packets) including instrument data plus any system ancillary data required by the end user to interpret his science data.
- Telecommand (transfer frames, virtual channels, packets) including instrument commands.
- Other services which are transparent to the end user including ground system monitoring, radio metric, RF tracking and acquisition, antenna positioning, and management

2.8 Scenario 8 - Teleanalysis Support

2.8.1 Example

Researchers require the ability to access and merge data from distant sources and perform analyses and studies on computers that may be remotely located. A science researcher typically correlates, analyzes, and processes existing data sets to produce new data sets that provide scientific revelations. This may eventually lead to planning some new mission to obtain data which currently do not exist.

The researcher first determines what data (e.g., non-proprietary data collected by one or more Space Station payloads) exist and determines its applicability to his research. To find existing data, the researcher may access Catalog and Directory Services to search the NSSDC Master Directory, various discipline Master Directories, catalogs, libraries, data dictionaries, and any other available sources. The researcher may also browse through some of the data to determine if it warrants full retrieval.

After locating and browsing data of interest, selected data sets or subsets and supporting metadata are requested. When the requested data sets are received, the local system must be able to retrieve the data from the transport media, check it for correctness and completeness, and then store it for later use.

For a particular investigation, a researcher will potentially require access to significant amounts of data, for example, access to an entire mission or to discipline data repositories. The local system must either be able to accommodate substantial volumes of data or an interactive high bandwidth link must be provided.

After successfully correlating, analyzing, and processing the requested data, the researcher may:

- Produce new data/information products for publication. In this case, the new data products will be registered with the appropriate Control Authority, the proper catalogs and directories will be updated as necessary, the data will be stored in a repository, and, of course, the results of the research will be published.
- Search for and retrieve additional data sets.
- Determine that available data are not sufficient for the investigation. To obtain the information, it may be necessary to fly a completely new instrument.

2.8.2 Definitions

- P Agency: Agency managing and maintaining databases of interest to scientific community
- U Agency: Agency requiring scientific data for analysis purposes

2.8.3 Description

Databases describing given classes of objects (e.g., Quasars, Earth-orbiting objects) are maintained by an Agency or an organization. Authorized U Agency users receive data from the databases. They also access multi-disciplinary information distributed at the various geographical locations and managed by various organizations. The results of an investigation are, in turn, made available for access by other authorized remote users.

2.8.4 Responsibilities

The P Agency manages the database and maintains a database directory. The P Agency provides the definition of the database to authorized U Agency users. The P Agency is responsible for the maintenance of the catalog of data accessible by authorized remote users.

2.8.5 Data Exchange

Data is provided to authorized users periodically, after each database update, or upon request.

2.8.6 Services

- Standard Formatted Data Units (SFDU) services including:
  - Control Authority
  - Data Registration and Distribution
  - Procedures Management
  - Report Management
  - Application and Environment
  - Data Definition Support
  - SFDU Processing

2.9 Scenario 9 - Ground Internetworking Support

2.9.1 Example

For its MOS satellite, NASDA required support from both CNES and ESA ground networks. A unique access point was provided to NASDA by CNES.

CNES provided not only a single access point (in terms of communication facilities) but also provided the network protocol conversion necessary to allow the X.25 protocol used between ESA and CNES to be converted into the protocol used between CNES and NASDA.

GSOC/DLR provided a gateway (performing the protocol conversion between the ESA X.25 network to the CNES NASCOM-like protocol) in order to allow CNES access to the tracking station at Malindi. This allowed CNES to access DLR's tracking station at Weilheim and ESA's tracking station at Malindi utilizing a simple protocol and a simple set of communications equipment.

2.9.2 Definitions

P1 Agency - Agency providing ground communication interconnection support (CNES)

P2 Agency - Agency providing support (e.g., tracking network) (ESA)

U Agency - Agency requesting the support (NASDA)

2.9.3 Description

The P1 Agency provides the U Agency access to P2 Agency support services.

2.9.4 Responsibilities

The U Agency provides request support schedule to P1 and P2 Agencies. P1 Agency schedules, monitors, and controls its ground network between U Agency and P2 Agency.

2.9.5 Data Exchange

- Telemetry data
- Telecommand data

2.9.6 Services

- Gateway services

2.10 Scenario 10 - Videoconferencing Support

2.10.1 Example

During the one week German Spacelab Mission D1, analog video and audio data was required to be transmitted from space to the Payload Operations Control Center in Oberpfaffenhofen via the NASA facilities in the United States and audio data was required to be transmitted in the opposite direction. This requirement will be extended in the space station era when near continuous digital audio and video data will need to be routed not only to the United States and Europe but also to Canada and Japan. (Note that the transmission of real-time video from the ground to space is not considered here).

2.10.2 Definitions

P Agency - Agency transporting digitized audio and video data from space to the ground (NASA)

U Agency - Agency conducting the operations to which the audio and video data applies (ESA)

2.10.3 Description

Audio and video data generated on-board a spacecraft by U Agency is transmitted by P Agency resources to the U Agency operations control center. Audio data generated on the ground by the U Agency is transmitted to the spacecraft by P Agency equipment. The transmissions are timed such that the downlink audio and video are synchronous and the uplink and downlink audio allow a normal conversation to be conducted between ground personnel and flight crew.

2.10.4 Responsibilities

The U Agency is responsible for generating audio and video data and delivering it to the appropriate CCSDS communications service. The P Agency is responsible for transporting the data through the Space Link Subnetwork in both directions, and for ensuring that the timing requirements of the data are satisfied.

2.10.5 Data Exchange

The U Agency operations control center is provided with synchronized, digitized audio and video data from on-board the spacecraft.

Where applicable, the U Agency crew member is provided with conversationally-synchronized audio from the operations control center.

2.10.6 Services

- Audio and video downlink
- Audio uplink
- Other services which are transparent to the end user including ground system monitoring, radio metric, RF tracking and acquisition, antenna positioning, and management.

3 SPACE DATA SYSTEM MODEL

3.1 Generic Space Data System Model

This section presents a generic model of a Space Data System, described in terms of the functions performed by each of the basic elements of the system. In this section, operational aspects of exchanging information between on-board and ground entities will be discussed. Later in this document, in section 4, the management aspects of the system will be addressed. Figure 3.1-1 presents a graphic depiction of a space data system model from the perspective of a single generic space agency.

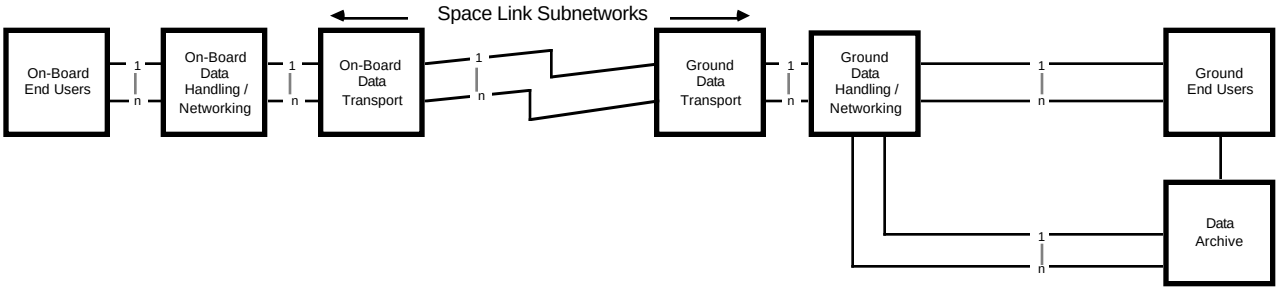

Figure 3.1-1 Generic Agency Space Data System Model

Seven basic components of the Space Data System Model are postulated, with the interfaces depicting the points along the space data system at which cross support is normally accomplished. Section 4 expands on this topic. It should be noted that there is an implied symmetry between the two on-board data handling and data transport components and the two similar components on the ground. The following paragraphs describe the basic elements of the Space Data System Model in terms of the forward link and return link related functions performed by each. The forward link is generally regarded as the flow of information/data from right to left in figure 3.1-1 while the return link is the flow from left to right.

3.1.1 On-board End Users

The On-board End Users are experiments, payloads, systems (or astronauts) which interface with the On-board Data Handling / Networking entity.

3.1.2 On-board Data Handling / Networking

The On-board Data Handling / Networking return link function accepts data from science payloads and other applications including system house-keeping. These data are multiplexed and then introduced into the on-board data transport system for transmission, or transported to another on-board system on the same spacecraft.

The On-board Data Handling / Networking forward link function receives data from the On-board Data Transport, processes the data and extracts commands, voice, video, text and graphics for distribution or storage as required. The On-board Data Handling also distributes ancillary data such as time and attitude information.

3.1.3 On-board Data Transport

Virtual Channels of data from the On-board Data Handling / Networking component are multiplexed, formed into transfer frames, encoded and modulated onto the RF return link signal for transmission to the Ground Data Transport System.

The On-board Data Transport component receives forward link transmissions from the Ground Data Transport System which it demodulates, decodes and extracts data for further processing by the On-board Data Handling / Networking system. The On-board Data Transport system also manages the space-ground link protocol.

3.1.4 Ground Data Transport

The Ground Data Transport component provides the acceptance of forward link data structures and transmits them on the RF-link. In order to accomplish this, it is necessary to provide facilities for the generation of virtual channels and transfer frames, encoding, modulation and the management of the ground to space link.

For the return link, this component provides the functions of demodulation, decoding, transfer frame synchronization, and the distribution of transfer frames and virtual channels.

3.1.5 Ground Data Handling / Networking

On the return link, the Ground Data Handling / Networking component accepts data structures from the data transport and provides data reassembly with optional processes for reversing, merging, and time ordering of playback data. This entity includes the normal Control Center functions.

The Ground Data Handling / Networking component also provides functions such as data decommutation, conversion to engineering/scientific interpretable products, and calibration according to predicted or predefined data. In addition, the component may perform various specific corrections on the data or correlation of data with other data or with time.

As a result of return link data processing, it may be necessary to formulate adjustments to on-board equipment. Thus, commands are constructed in preparation for routing to the spacecraft.

On the forward link, the Ground Data Handling / Networking component provides the collection and formatting of data in order to prepare it for data transport.

In general, this component also formats the processed data for archival and/or transmission to the end user and provides data logging facilities.

3.1.6 Ground End Users

Ground End Users are entities which interface with the Ground Data Handling / Networking entity and which initiate data transfers and/or receive and process data from the DTS. Examples include spacecraft operators, scientists, automatic data reception facilities, and applications.

3.1.7 Data Archives

The functions performed by the Data Archives component are related to storage and subsequent access of previously stored data for correlative data analysis and/or decision making during mission operations. Typical functions include data archive management , updating of data directories and catalogues, search, browse and retrieval of relevant data.

3.2 Cross Support Model for Operations

Figure 3.2-1 presents a slightly simplified view of the generic space data system model with the addition of CCSDS Cross Support Points (CSP's) placed at the appropriate logical locations. It is at these CSP's that User Agencies are able to access the resources and services of Provider Agencies described in Section 3. These CSP's are derived as a result of compiling the comprehensive set of scenarios documented in section 2. A CSP is established at each logical point, along the generic space data system model, where services are cross supported in the scenarios.

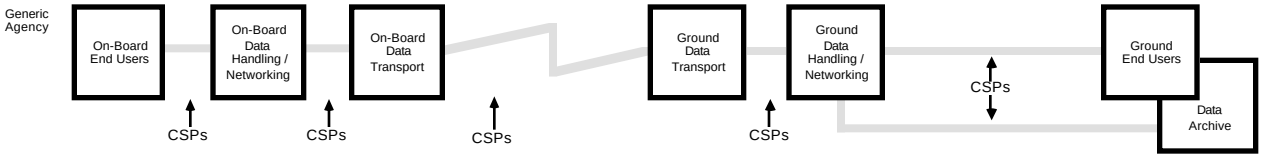

Figure 3.2-1 Generic Space Data System Model with CSP's

In order to illustrate the cross support environment involving multiple space agencies, the generic space data system model is simply duplicated to create a Cross Support Model showing multiple space agencies in a cross support environment. This is shown in figure 3.2.2.

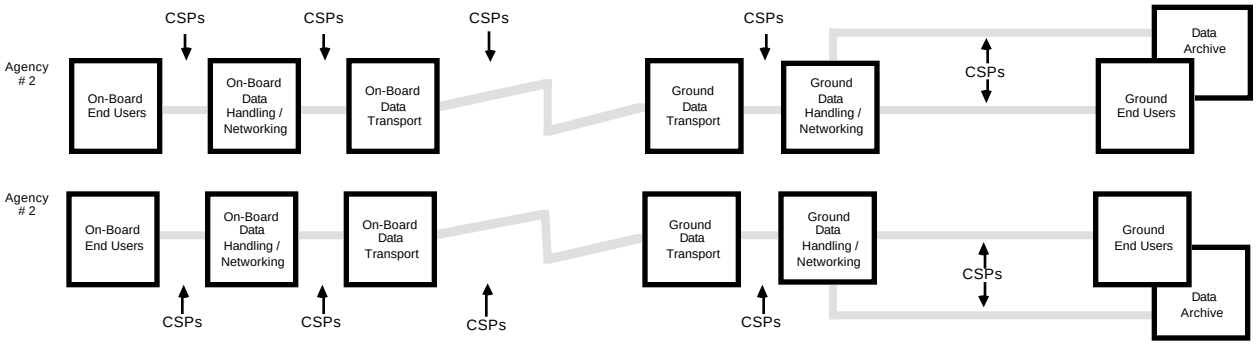

Figure 3.2-2 Cross Support Model

This cross support model can be used to illustrate the involvement of space data system resources in each of the scenarios identified in section 2. Figures 3.2-3 through 3.2-10 illustrate the resources used by each of the participating agencies regarding cross support in each of the scenarios. Each diagram replicates the multiple agency cross support model and shows a bold solid line through the diagram to indicate the resources used by each agency participating in the cross support activity. Following each diagram is a short narrative that walks the reader through the model for each scenario. Note that only selected scenarios are included. While some scenarios were included in section 2 to document how cross support has been accomplished in the past, it is deemed that cross support will not necessarily be accomplished the same way again. Therefore, such scenarios are not included here.

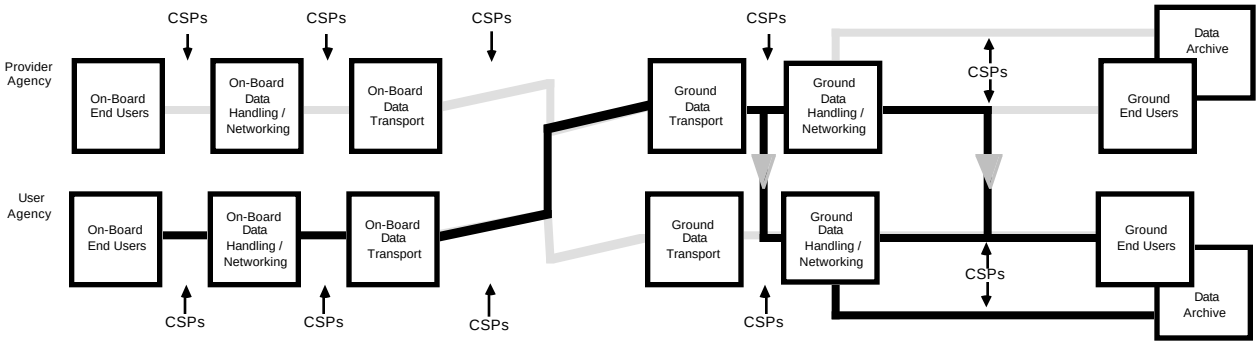

Figure 3.2-3 Cross Support Scenario 3 - TT&C Network Support

In this cross support scenario, user data from the user spacecraft are received at the provider's ground station. Depending on the cross support level provided, data will be provided to the user in the form of transfer frames, virtual channels, or packets. In a similar manner, telecommands created by the user may be radiated through the provider's ground system to the user's spacecraft.

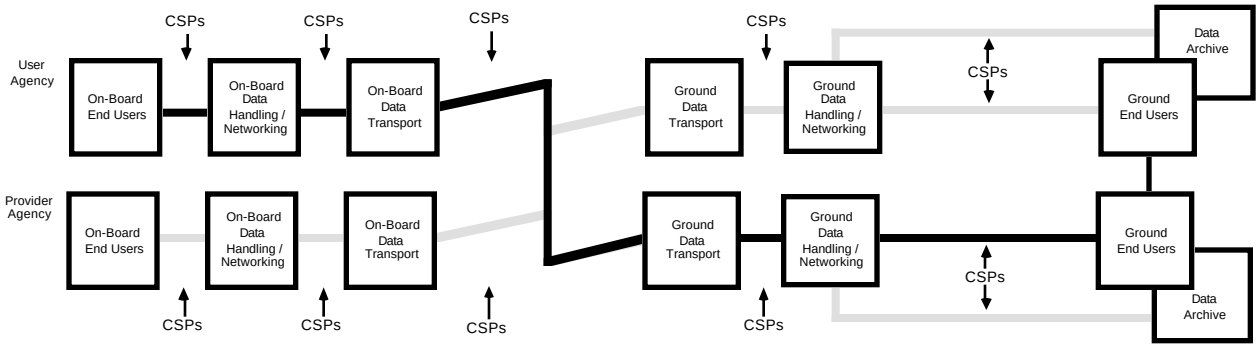

Figure 3.2-4 Cross Support Scenario 4 - Spacecraft Monitor and Control Support

In this particular example, the concept of a backup spacecraft control center is shown. The P Agency monitors and controls the spacecraft in a manner established in cooperation with the user agency.

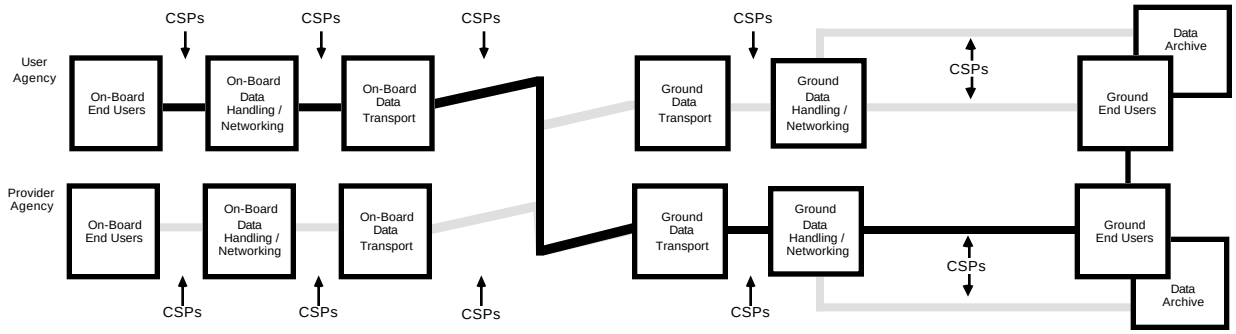

Figure 3.2-5 Cross Support Scenario 5 - Single Spacecraft, Multi-Agency Instruments

Housekeeping telemetry and science data from the instrument of the U Agency is delivered to the on-board data handling operated by the P Agency. The P Agency merges the U data with data coming from other instruments and transports it to the ground. The ground data handling of the P Agency extracts the U Agency data and delivers it to the U Agency science data facility. The P Agency may also provide ancillary data (eg. Attitude, Time).

To control its instrument, the U Agency has to provide the appropriate set of commands to the ground data handling facility of the P Agency)eg. Control Center). The P Agency merges these commands with other command data and sends it to the spacecraft at the appropriate time.

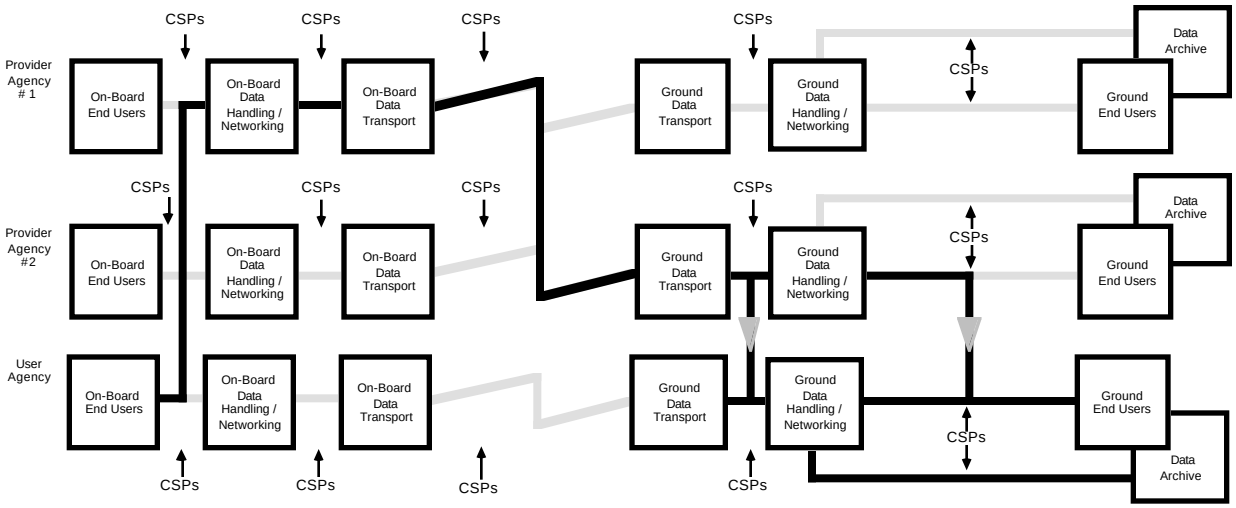

Figure 3.2-6 Cross Support Scenario 6 - Multi-Spacecraft, Multi-Agency

The housekeeping and science data, generated by instruments operated by the U Agency on-board the P1 Agency spacecraft(s), are received by the P2 Agency which is responsible for the TT&C operations of the spacecraft(s). The science telemetry data are delivered uncalibrated (ie. raw) or calibrated (ie. processed), along with the required auxiliary data, such as orbit data and timing information, to the U Agency which is responsible for the scientific utilization of the mission.

To operate the on-board instruments, the U Agency provides the P2 Agency with the payload observation schedule and payload telecommands. The data is then delivbered to the P1 Agency spacecraft)s). The data interchange (ie. telemetry / telecommand) between the U and P2 Agencies can occur in real-time, during observation periods, or off-line.

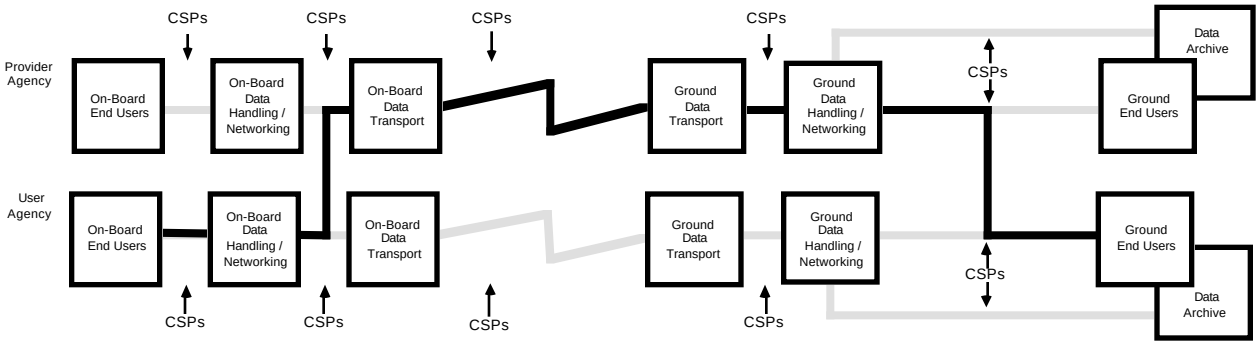

Figure 3.2-7 Cross Support Scenario 7 - Telescience

Housekeeping telemetry and science data from the on-board data handling system of the U Agency instrument feed into the spacecraft on-board data transport system operated by the P Agency. The P Agency transports the data to the ground and delivers it directly to the U Agency science data processing facility (such as a user operations center) where it is analyzed. As a consequence of this analysis, the U Agency science data processing facility may generate commands which will be routed to the U Agency instrument data handling system via the P Agency network.

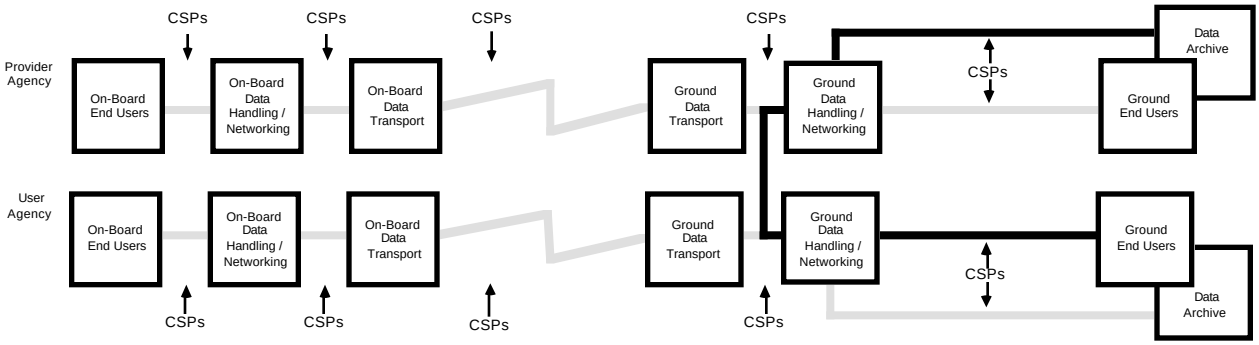

Figure 3.2-8 Cross Support Scenario 8 - Teleanalysis

In addition to the numerous services which the space data system provides during activities related to mission operations, there are those services which support information interchange associated with research. These services primarily support interactions among data bases. The interactions include:

- searching through catalogues and directories to determine the existence of data sets and their locations,
- accessing information which provides syntactic and semantic meaning of selected data sets,
- browsing through archived data to determine the content and relevant value of these selected data sets,
- requesting selected data sets from data archives,
- generating and sending requested data sets together with supporting information in standardized formats, and
- having access to interpretive tools such as parsers and data languages.

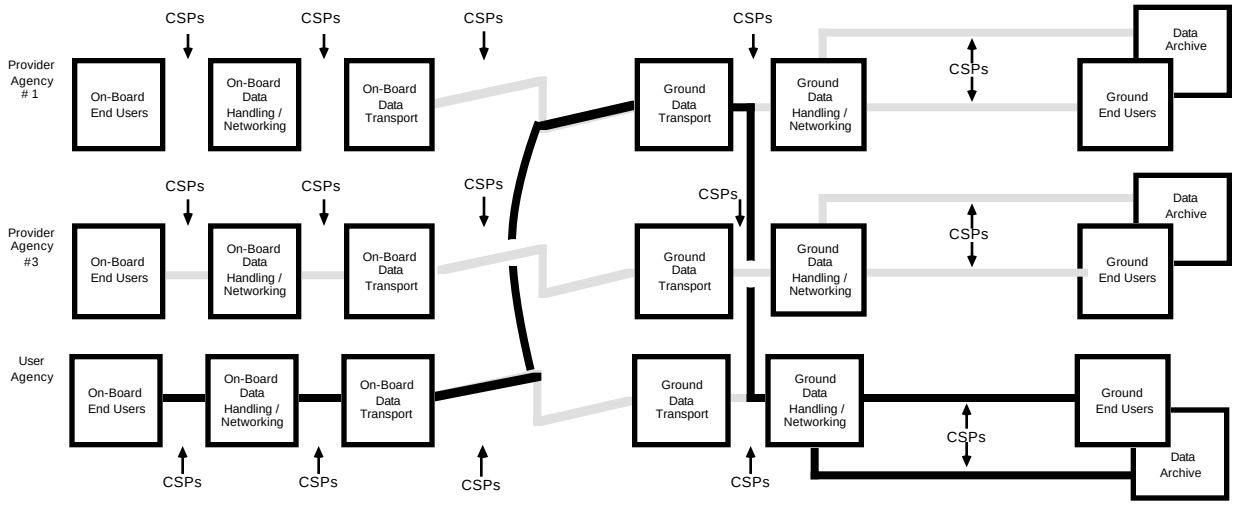

Figure 3.2-9 Cross Support Scenario 9 - Ground Internetworking

Sometimes, in current cross support situations, support is required from several networks. Not all of these networks may be compatible. Provided, however, two compatible provider networks cooperate, it is often possible to provide service to a user who is incompatible with the networks.

In the example described previously, CNES required the support of the ESOC tracking station in Malindi; the CNES ground network is incompatible with the ESA ground network. DLR, however, has inter-network software, which allows DLR to access the ESOC network and provide the required service to CNES.

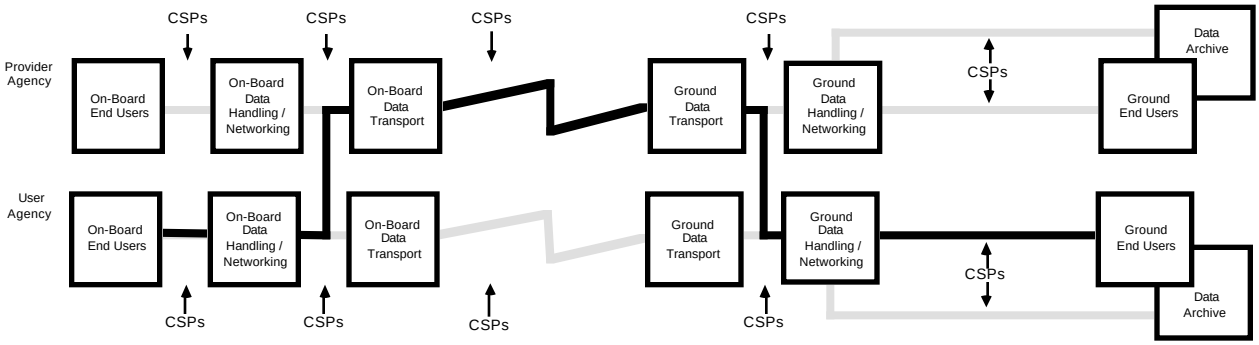

Figure 3.2-10 Cross Support Scenario 10 - Videoconferencing

Audio and video data from the on-board data handling system of the U Agency feed into the spacecraft on-board data transport system operated by the P Agency. The P Agency transports the data to the ground and delivers it directly to the U Agency ground data handling facility (such as a regional control center) where it is processed and routed to science data processing facilities as required. The U Agency ground data handling facility generates audio (and possibly routes audio from the science facilities) which is then routed via the P Agency network to the U Agency on-board systems.

4 CCSDS CROSS SUPPORT CONCEPT

Section 4 presents the CCSDS cross support concept. The underlying principle for this concept is that agencies whose space data systems adhere to the CCSDS Recommendations can interact with other agencies in a common standardized way. The concept introduces the simple notion of a "CCSDS Virtual Agency" as a logical entity whose space data system interfaces are completely specified by CCSDS and its Recommendations. The space data systems of CCSDS member agencies emulate the Virtual Agency at these interfaces.

For the cross support Scenarios, this section then shows where agency interconnections occur on the generic space data system model introduced in the Section 3.

Finally, management entities and associated interfaces are presented. In a manner analogous to the generic model in Section 3, these management entities are also fundamental elements of any Agency's space data system operations; that is, without regard for cross support considerations.

Section 5 of this document will address the interactions between space agencies at the management interfaces defined herein.

4.1 CCSDS Cross Support

Cooperation among CCSDS member agencies in space missions is not new. For more than 15 years, member agencies have supplemented their own internal resources and capabilities with those of other agencies.

The capabilities provided, whether pre-planned or in response to an emergency, are referred to as cross support. For many CCSDS member agencies, resource sharing or cross support in one form or another is an essential feature of most of their flight mission activities. For these agencies, cooperation in the planning and execution of spaceflight missions is an on-going way of life.

There are numerous advantages in using the resources of others. Historical examples include:

- additional tracking network coverage
- launch and transfer orbit support
- emergency backup support and redundancy
- reduced overall costs via cooperative missions

However, as the space agencies enter the next decade, other drivers toward more widespread cooperation will come into play. These include:

- the thirst for increased "science return" via multiple agency correlative research efforts and access to multi-mission data archives
- the increase in complex missions beyond the limited resources of any one agency

In traditional terms, "cross support" does not imply any commitment to data systems commonality or to standards, even though such common standards may indeed significantly ease the implementation of that cross support. The agency requesting support has provided on a case-by-case basis any necessary interface or black box to adjust for data system incompatibilities.

In contrast, the CCSDS stresses standardized cross support capabilities and thereby places substantial emphasis on interoperability among the elements of member agency space data systems. A common space data system model is defined in order to expose potential interfaces for standardization. The model defines data system interfaces during the active operations phase for a particular mission as well as during a "post-mission" phase involving data retrieval from an archive.

The collection of standardized capabilities in effect defines a "CCSDS Virtual Agency". This "Agency" is a logical construct and not a real or physical entity. According to this view, CCSDS Recommendations specify various features of the "Agency". The degree to which the individual CCSDS member agencies adhere to the CCSDS Recommendations can be interpreted as the degree to which they emulate the "CCSDS Virtual Agency". The "specification" is limited to data system interfaces, allowing the member agencies freedom with respect to "internal" implementation, as long as the interface is "matched".

Figure 4.1-1 illustrates the traditional approach to cross support and provides a comparison view of the modified approach being promoted by CCSDS. Traditionally, a pair of half-gateways are developed for each inter-agency connection. The left side of the figure shows this and indicates the burden on an agency as new connections are added. The right side of the figure shows the impact of introducing the CCSDS Virtual Agency. Now, each member agency develops only one half-gateway. This half-gateway converts any agency unique characteristics into the common characteristics specified within the CCSDS Virtual Agency. At the other end of the connection, a second half-gateway converts the common characteristics into any unique characteristics of the second member agency.

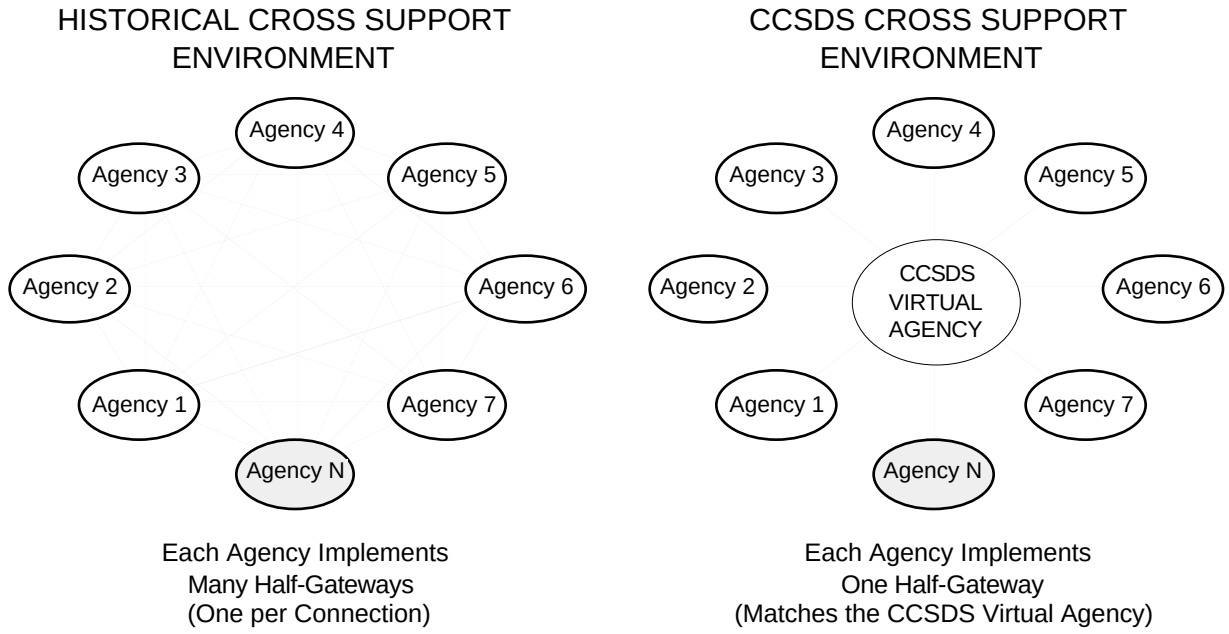

Figure 4.1-1 CCSDS Cross Support Concept

In addition to allowing a reduction in half-gateway development for the near-term, the CCSDS Virtual Agency provides a single and common evolutionary goal for the member agencies' individual space data systems. This means that in the long-term, the need for any gateways at all will be minimized to the degree that the agency-internal characteristics match those of specified by the CCSDS Virtual Agency.

Figure 4.1-2 provides a second view of CCSDS cross support. Again, the CCSDS Virtual Agency is "defined" by the collection of CCSDS Recommendations. Implementation of each agency's half-gateway is the individual responsibility of that agency. Also shown in the figure is the cross support view that end users logically access the interconnected space data system via their own agency and do not directly interface with another agency. The interface with an end user is defined by that agency through which services are obtained.

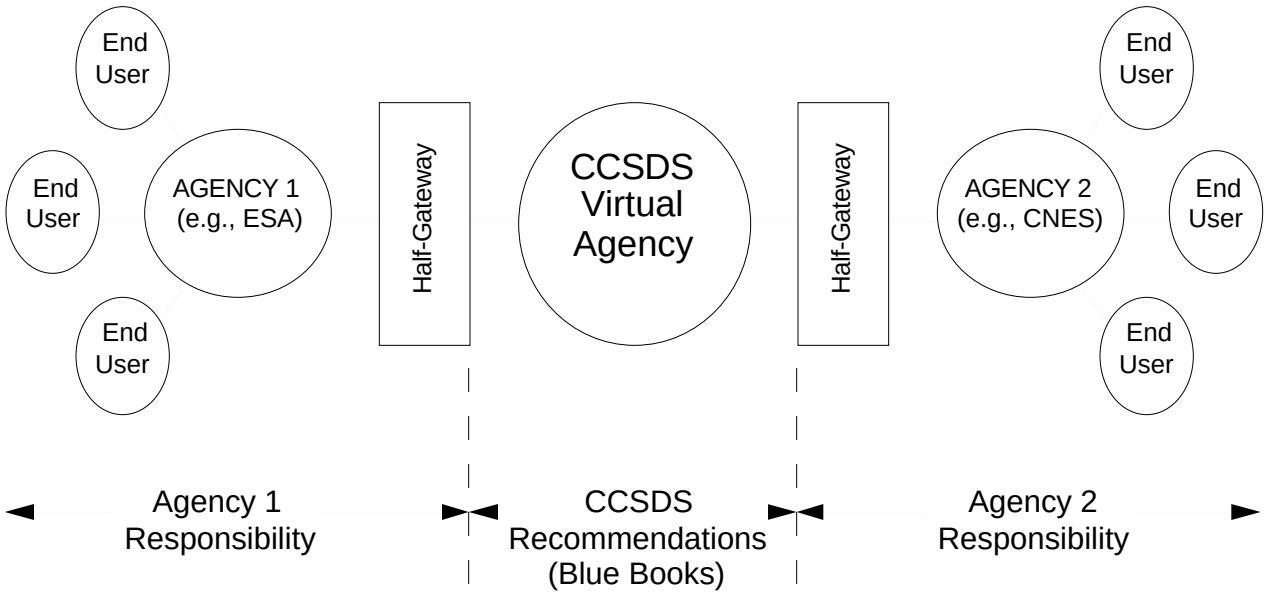

Figure 4.1-2 CCSDS Cross Support Principle

In describing standardized cross support, the CCSDS uses the notion of "services" in a manner broadly similar to the use of the term by the International Standards Organization (ISO) in their Reference Model for Open System Interconnection . In the CCSDS context, a service can be defined as the "external appearance of functions and capabilities made available by a providing agency to a requesting agency ". The notion is that a capability of a system is provided to another system in accordance with agreed (prescribed) conventions at the interface between those two systems. The advantage in adopting this "service viewpoint" is that a detailed knowledge of the internal mechanisms of the providing agency is not necessary; the essential features of cross support are captured by specifying the interface.

Representative CCSDS cross support services include data acquisition and communications services, processing services, information management and retrieval services, mission operations management services, and so forth.

The specific services used in support of a particular mission are negotiated on bilateral agency basis through agreements such as memoranda of understanding (MOU). Traditionally, an agency requesting support has either paid for support, or operated on the basis of some special arrangement (e.g., network tracking support in exchange for sharing experiment data). The CCSDS concept does not alter the need for this early "negotiation" aspect of cross support. Once authorization/access to a service has been negotiated, the services are invoked at cross support points using the access protocols specified in CCSDS Recommendations.

Standardized cross support must also be based on a management concept which ensures the coordination among separate activities within the two agencies. The management concept presents the "how&when" needed to complement the "what&where".

The CCSDS management concept for cross support is based on the notion that agency resources involved in a given instance of CCSDS cross support remain under the direct control of that agency and the appropriate management entity within that agency.

An important distinction can be drawn between "resource management" and "service management". As previously stated, each individual agency directly manages the resources within its space data system. This can be viewed as an "inward-looking" activity.

The CCSDS, on the other hand, is concerned with the interface between agencies and is concerned with management of that interface and of the services provided at the interface. In general terms, the cross support management concept includes :

- Allocation of agency management roles and responsibilities
- Definitions of what is managed and how
- Definition of the rules of interaction among the management entities

Within CCSDS, the concept is limited to functional entities. As was previously shown with the definition of the "CCSDS Virtual Agency", a "virtual manager" can be composed of cooperating peer-level agency management entities interacting via a manager-to-manager dialog using common protocols and common management procedures. Figure 4.1-3 provides a simplified illustration. This figure expands on the logical construct of the CCSDS Virtual Agency introduced earlier.

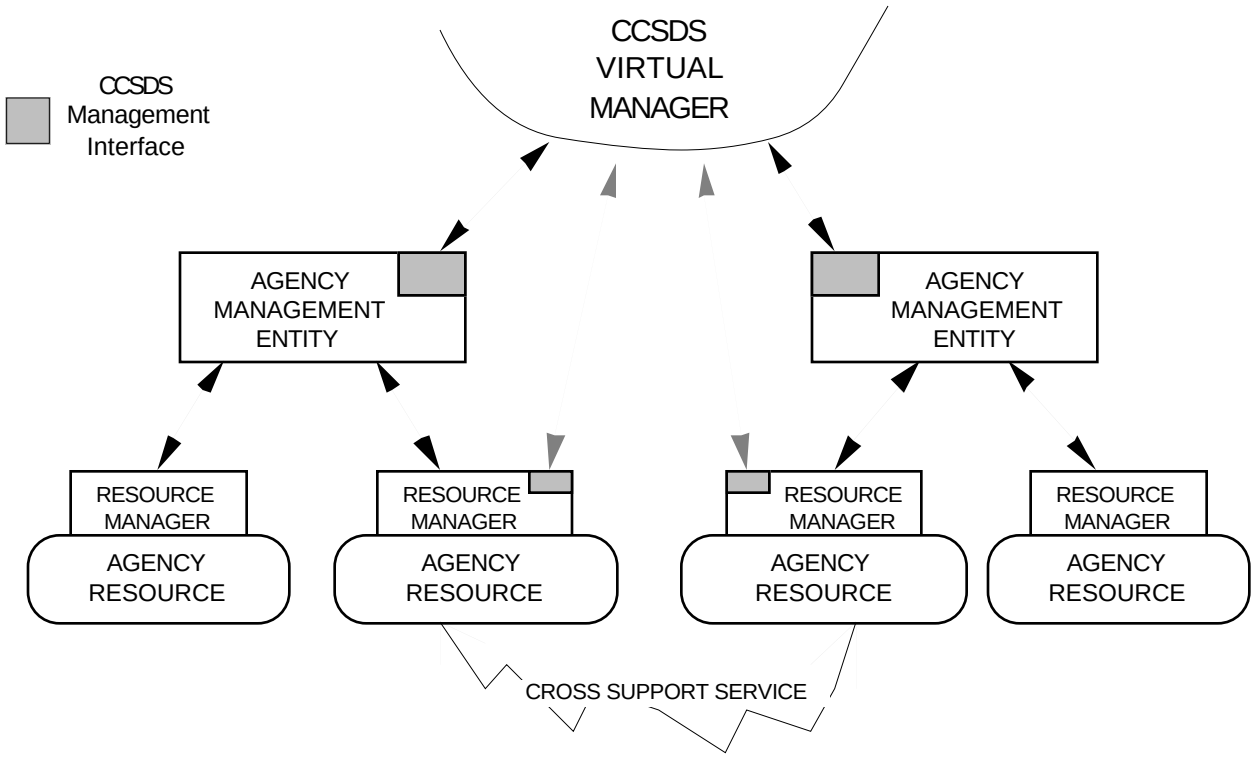

Figure 4.1-3 CCSDS Virtual Management Concept

In this figure, a management entity within the agency requesting cross support acts on behalf of that agency as a part of the overall CCSDS virtual manager. Similarly, the management entity peer within the providing agency also acts as part of the virtual manager. What this means is that the two entities interact in accordance with a set of rules and procedures prescribed by CCSDS and common to all member agencies engaged in instances of cross support. These rules, protocols and procedures are specified in the CCSDS Recommendations.

Resources within either the requesting agency or the providing agency are directly controlled by "local" resource managers within the specific agency. A "private" agency-unique protocol may be used between the local managers and their resources for control of those resources. Since the CCSDS is not concerned with the direct management of physical resources, it only has a need for a manager-to-manager protocol to exchange management information about the services defined by CCSDS Recommendations.

The figure shows two possible configuration options. In one case, denoted by the solid lines, agency interaction occurs in a strictly hierarchical fashion. Individual resource managers do not interact directly with their counterparts in the other agency. Rather, the interactions occur through "higher level" management entities as shown. This is true even after initial dialogs are established; CCSDS cross support management dialogs continue to flow through these entities as the cross support service is being implemented. This centralized architecture has been dominant historically among most of the member agencies.

In the second case, denoted by the dotted lines, agency interactions occur directly involving individual resource managers acting as part of the CCSDS virtual manager. The initial "set-up" for this option may have occurred via the management entities above; once established, actual implementation of the cross support is handled at this level without the direct intervention of those entities. This configuration is less prevalent historically but is viewed as becoming more popular as distributed processing technology matures.

4.2 Space Data System Management Entities

Space data system management entities control the resources used by a space mission. These entities interact with each other so as to yield a coordinated activity in conformance with the mission plan and timeline. For cross supported missions, these entities also may interact with their counterparts in the second agency. As with most complex systems, modern space flight missions include both hierarchical (layered) and distributed management structures.

The top level management entity in each CCSDS member agency is responsible for strategic planning and associated issues. For a cross supported mission, this includes negotiating the broad terms of the cross support and responsibilities of the two agencies via a Memorandum of Understanding (MOU), Memorandum of Agreement (MOA), or similar top-level authorization document. Also at this level, contractual and other fiduciary elements outside the scope of the present treatment are handled.

Each of the Scenarios presented in Section 2 included a brief summary of agency "responsibilities" under that particular Scenario. These responsibilities are generally specified at the top level authorization document. Within the general framework of this document, lower level management entities will subsequently negotiate and start to develop the specific terms of the cross support and to define the specific technical interfaces between the two agencies. At this next level down, documentation often takes the form of Support Instrumentation Requirements Documents (SIRD) and Interface Control Documents (ICD).

The specific architecture of management entities at this next level varies with each CCSDS member agency. However, a generic structure is proposed as shown in Figure 4.2-1 for characterizing the space data system management entities at this level within the CCSDS Virtual Agency.

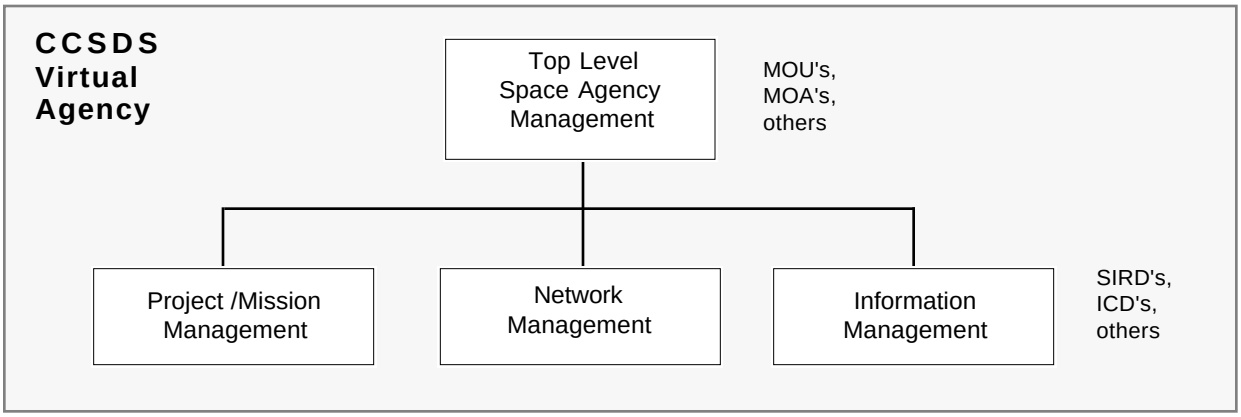

Figure 4.2-1 Generic Management Structure

Three generic entities are proposed:

(1) Project/Mission Management

(2) Network Management

(3) Information Management

For a mission implemented within a single agency, these three entities interact with one another exchanging various requests, messages, and status information.

Each of the three management entities has the responsibility to allocate and manage the resources of a specific portion of the space data system.

4.2.1 Project/Mission Management (P/MM)

The Project/Mission Management entity provides the overall planning and guidance for the mission including the development of the mission timeline. It is also responsible for actual flight spacecraft operations and coordination of the other operational elements of the mission. The following are typical functions performed by this entity:

(1) Manage overall project risk

(2) Coordinate resources

(3) Monitor spacecraft status

(4) Ensure mission objectives

(5) Produce schedule - planning

(6) Identify functional interfaces

(7) Manage project operations

(8) Manage spacecraft operations and configuration

4.2.2 Network Management (NM)

The Network Management entity provides the institutional support resources such as tracking stations, ground communications, orbit and attitude computational facilities, and so forth. The following are typical functions performed by this entity:

(1) Test compatibility

(2) Select network tracking stations

(3) Schedule and manage resources

(4) Manage inter-network interfaces

(5) Analyze tracking and data acquisition performance

(6) Determine orbit, trajectory, and ephemeris

(7) Coordinate frequency assignment

(8) Operate spacecraft (telemetry, telecommand)

(9) Perform time tagging of events

4.2.3 Information Management (IM)

The Information Management entity provides the discipline specific expertise, including analysis and interpretation of mission data products, and definition of specific mission observation/measurement sequences. The following are typical functions performed by this entity:

(1) Process and enhance data

(2) Analyze data

(3) Register data (i.e., metadata)

(4) Calibrate instruments

(5) Distribute data (e.g., weather products)

(6) Establish science objectives

(7) Develop application/science strategy

(8) Manage application/science resources

(9) Analyze and assess performance

(10) Manage inter-archive interfacing

(11) Manage campaigns (multi-satellite coordinated science management)

4.3 Management Cross Support Points

The intersection of each User and Provider Agency management entity is a potential management interface. These interfaces are Management Cross Support Points (MCSPs), i.e., MCSP-1, MCSP-2, and MCSP-3. It is acknowledged that there is a considerable amount of interaction between the user and provider agencies at the Agency "contractual" and "informational" level. However, this interaction is not singled out as a separate MCSP. This includes the negotiation of the high level terms of cross support and the responsibilities of the user and provider agencies often documented in Memorandum of Understanding (MOU) and Memorandum of Agreement (MOA).

4.3.1 Primary Management Interfaces

Via MCSPs, User Agencies access the management entities of potential Provider Agencies to negotiate and ultimately establish cross support relationships. Figure 4.3-1 presents the User and Provider Agency management entities, MCSPs, and primary management interfaces.

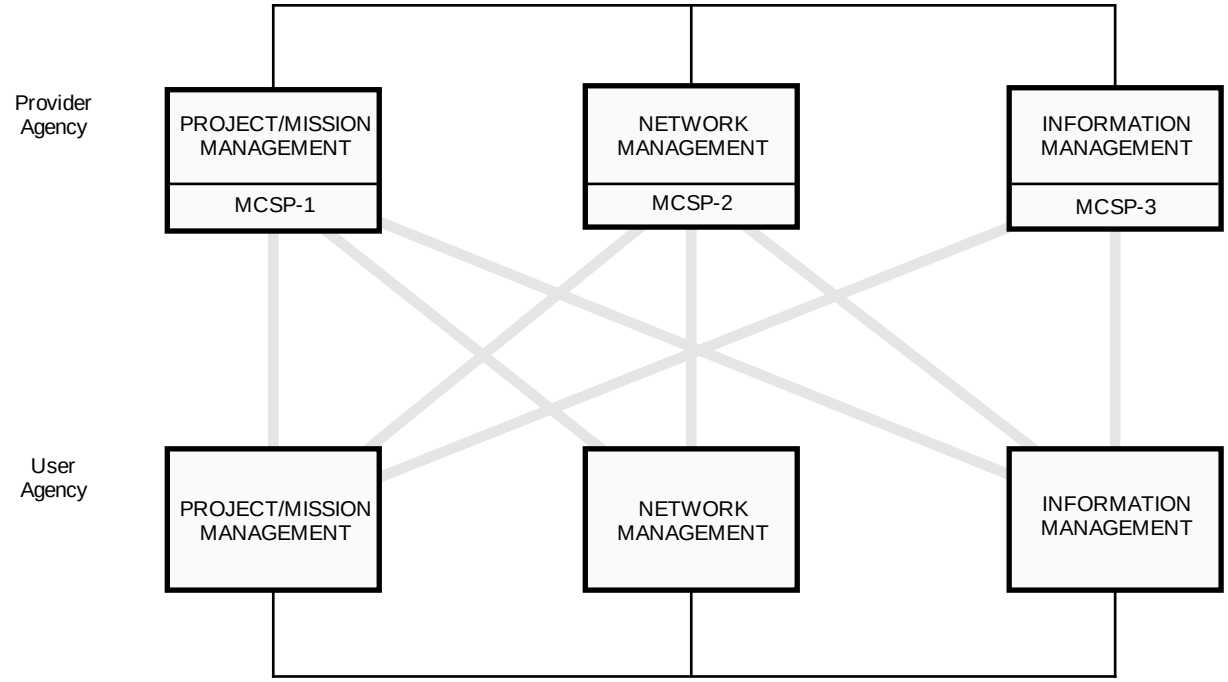

Figure 4.3-1 Primary Management Interfaces

4.3.2 Typical Requests and Responses at MCSP's

This section presents MCSP protocols (i.e. the typical User Agency requests/inputs to each MCSP and the resultant Provider Agency responses/outputs).

The following are typical User Agency requests/inputs at the MCSP's which include high-level requests for information about access and low-level requests for information about the availability and access to resources.

MCSP-1 High-level requests for permission to obtain information about access to instruments, spacecraft, tracking station, network, facilities, and databases.

MCSP-2 Low-level requests for information about future availability of (eg. schedules) and access to (eg. Support Instrumentation Requirements document - SIRD) resources such as tracking stations, networks (line and circuits), computer facilities, orbit determination, spacecraft control, and services.

MCSP-3 Requests for metadata and associated data, ancillary data, subsetting, special processing, expert support, science support and resources, and participation in campaigns.

The following are typical Provider Agency responses / outputs from the MCSPs which include formal responses:

MCSP-1 Responses include acknowledgements, information, and rejections with supporting information.

MCSP-2 Responses include revised SIRD, ICD / Mission Support plan, schedules (sequence of events), reports, and permission to use resources and/or services.

MCSP-3 Responses include catalogs, confirmation of actions to be taken, and expert support.

5 CCSDS CROSS SUPPORT MODEL

The various elements and features of cross support have been presented in the preceding sections. This section integrates these components into an overall abstract model of CCSDS cross support.

5.1 ABSTRACT MODEL OF CCSDS CROSS SUPPORT

Figure 5-1 presents an abstract model depicting the major functional entities and interfaces involved in CCSDS cross support. This model includes those elements associated with management as well as those directly associated with the transport, handling, processing, and archiving of space mission data.

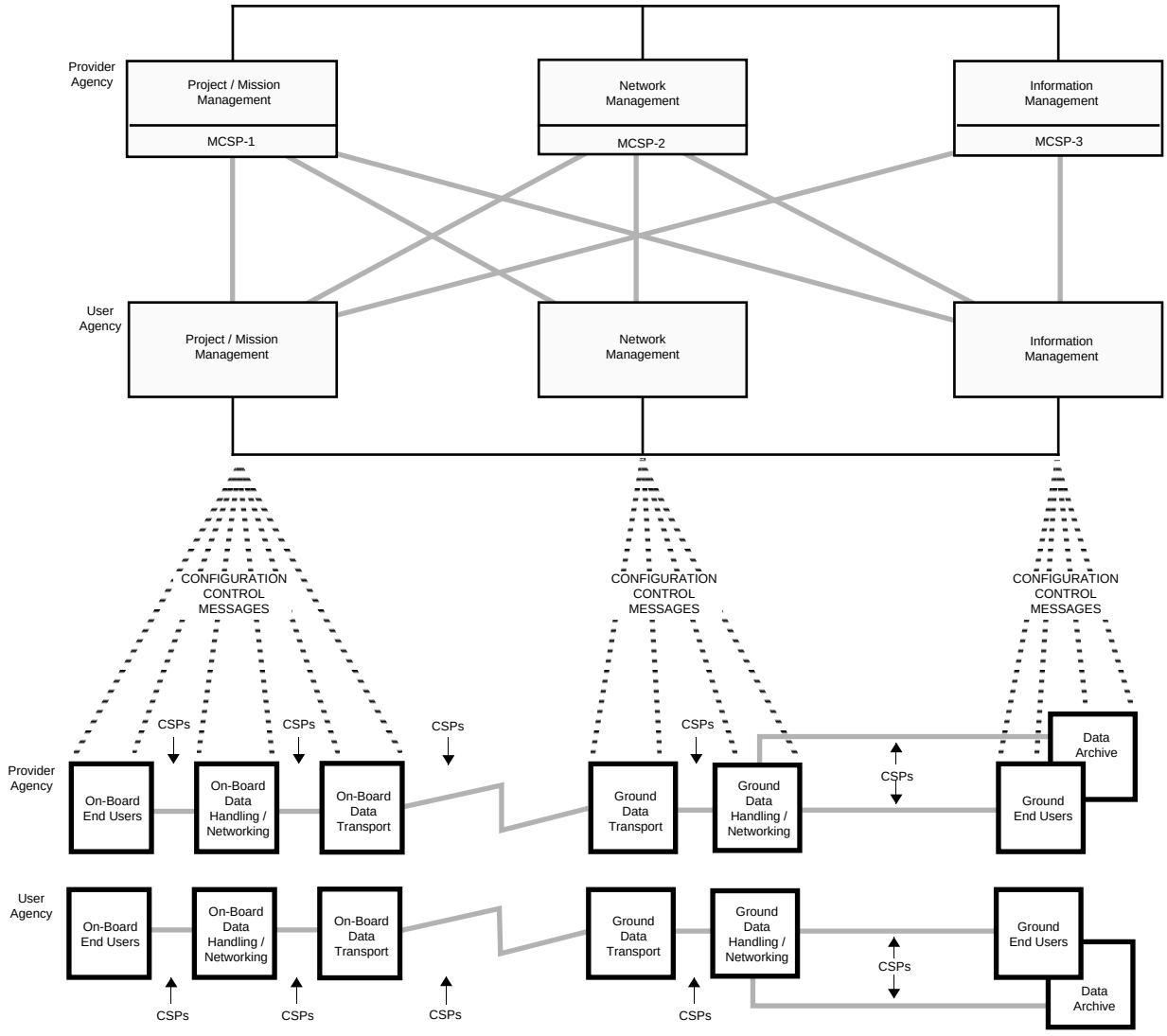

Figure 5-1 Overall CCSDS Cross Support Model

5.2 MANAGEMENT INTERACTION

The CCSDS cross support management concept recognizes a top level entity in each agency which is responsible for strategic planning and associated issues. The top level entity either has the authority or has been delegated the authority (for that particular cross support effort) to commit the agency's resources. As was previously stated, this includes negotiating the broad terms of the cross support and the responsibilities of the two agencies via a Memorandum of Understanding (MOU), Memorandum of Agreement (MOA), or similar top-level authorization document.

This initial "authorization" with respect to use of agency resources is a key and necessary first step in the CCSDS concept of cross support. However, aside from defining the role and relationship of this first step to the ensuing cross support, the CCSDS concept does not call for specific standardization at this top level interface. The top level interaction occurs in both kinds of cross support; that is, in the mission operations domain as well as the archival database access domain. In some cases such as cross support provided to a particular flight mission or the blanket approval for access to a given science discipline database, the top level interaction may occur only once, with all subsequent agency interactions occurring between the lower level management entities identified in Section 4.4. In other cases, several top level interactions may occur during the life of the cross support.

As was described in Section 4.4.1, space data system management entities interact with each other in order to coordinate their activity in conformance with some overall mission plan. Under cross support, one or more of these entities residing in one agency may interact with one or more entities in the second agency.

In Section 4.5, a set of Management Cross Support Points (MCSP) were defined whereby entities and interfaces were logically grouped to illustrate where access occurs to Provider Agency management entities so that a cross support relation can be established and maintained. In order to further illustrate this notion, the interactions at these MCSP's can be described using the Scenarios.

5.2.1 Scenario 1 Management Interactions

Scenario 1 was included in section 2 because of its actual cross support application. However, as in section 3, it is not expected that such cross support will occur again. Therefore, management interactions of this scenario are not considered here.

5.2.2 Scenario 2 Management Interactions

Scenario 2 was included in section 2 because of its actual cross support application. However, as in section 3, it is not expected that such cross support will occur again. Therefore, management interactions of this scenario are not considered here.

5.2.3 Scenario 3 Management Interactions

The User Agency P/MM must first determine if the Provider Agency can provide tracking support . The User Agency P/MM approaches the Provider Agency. Should the Provider Agency be in a position to provide the required support, it will respond by permitting User Agency P/MM to contact the Provider NM. User Agency P/MM then approaches the Provider NM and negotiates the required support. The User Agency NM accesses the Provider NM for detailed technical information (e.g., schedules) throughout the duration of the support.

5.2.4 Scenario 4 Management Interactions

A project, User Agency P/MM, with limited resources requires another agency, the Provider Agency to provide a back-up control center. User Agency P/MM requests support. The Provider Agency responds and permits User Agency P/MM to contact the Provider NM. User Agency P/MM interacts with the Provider NM. The Provider NM provides required informations (e.g., SIRD, mission analyses, operations manuals, spacecraft manuals, telemetry and telecommand databases, and software requirements. User Agency P/MM will coordinate with the Provider NM for schedules and will exchange applicable spacecraft status and data.

5.2.5 Scenario 5 Management Interactions

The management interaction which occurs for scenario 5 is illustrated in Figure 5-2 using the Overall CCSDS Cross Support Model. The User IM interacts with the Provider P/MM (step A) to negotiate for support. During this step, mission characteristics and timelines are determined. In parallel, the User IM interacts with the Provider NM (step B) to identify and coordinate the specific services to be provided. Then, during flight operations, the User IM coordinates with the Provider P/MM (step C) regarding instrument utilization and timelines. The User IM also coordinates with the Provider NM regarding the receipt of data (step D).

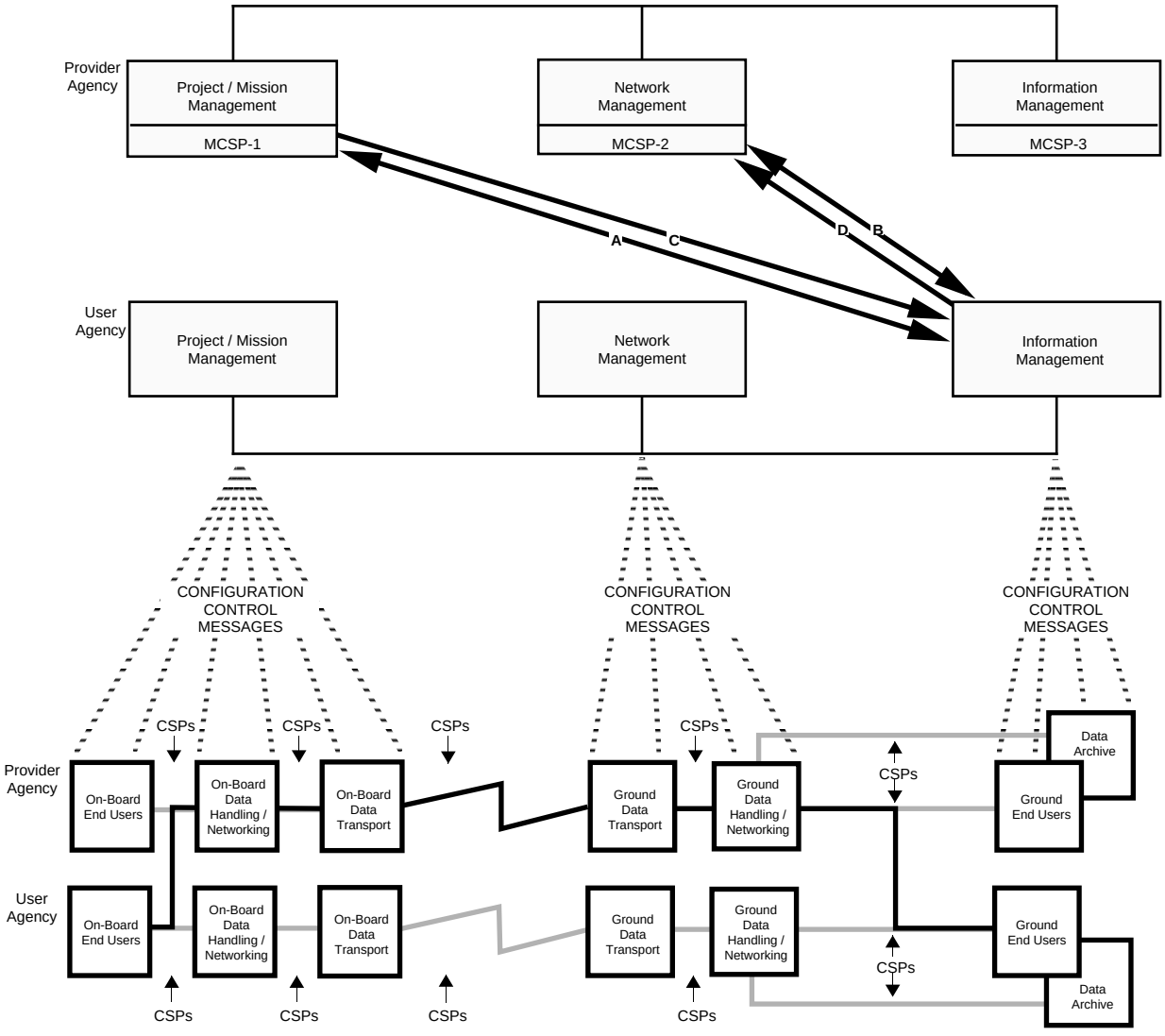

Figure 5-2 Scenario 5 Management Interactions

5.2.6 Scenario 6 Management Interactions

From a management point of view, Scenario 6 is a more sophisticated version of Scenario 5. Therefore, it will not be addressed in this section.

5.2.7 Scenario 7 Management Interactions

An User IM attached to a User P/MM wishes to interact in real-time with an instrument on-board a spacecraft operated by a Provider P/MM. The User IM, the User P/MM, and the Provider P/MM agree the operational constraints and resources limits which will govern the telescience session. Then during the session itself, the User IM will interact with the Provider NM to receive his data and transmit his commands. He will also interact with the User P/MM and the Provider P/MM if any replanning of the session is required.

5.2.8 Scenario 8 Management Interactions

In order to pursue a particular line of research, an experimenter, the User Agency IM, approaches an Agency, the Provider Agency to inquire about the existence of relevant scientific data. The Provider Agency permits the User Agency IM to contact the Provider IM. The User Agency IM interacts with the Provider IM. The Provider IM coordinates access to the data. Throughout this activity, the User Agency IM coordinates with the Provider IM.

5.2.9 Scenario 9 Management Interactions

From a management point of view, scenario 9 is a more sophisticated version of Scenario 3. Therefore, it will not be addressed in this section.

5.2.10 Scenario 10 Management Interactions

A User P/MM wishes to interact in real-time with the crew on-board a spacecraft operated by a Provider P/MM. After agreeing upon a timeslot with the Provider P/MM, the User P/MM will interact with the Provider NM to receive its audio and video data and to transmit its audio.

6 HIERARCHY OF RELATED DOCUMENTS

This section is designed to assist the potential user of CCSDS Recommendations locating additional information about the CSPs and MCSPs that have been introduced in the foregoing sections of this document. These services and protocols are further described in CCSDS documents listed below under the appropriate service series:

CCSDS SERIES	SERVICES
100	Return Link (Telemetry)
200	Forward Link (Telecommand)
300	Time Codes
400	Radio Frequency and Modulation
500	Radio Metric and Orbit Data
600	Standard Data Interchange Structures
700	Advanced Orbiting Systems
800	Ground Networks and Communications Systems
900	Space Data Systems Concepts and Services

The latest issues of these documents may be obtained from:

CCSDS Secretariat
Communications and Data Systems Division (Code TS)
National Aeronautics and Space Administration
Washington, DC 20546
USA

ANNEX A

ACRONYMS

ACRONYMS

AMPTE	Active Magnetic Particle Tracking Experiment
BNSC	British National Space Center
CCSDS	Consultative Committee for Space Data Systems
CDHF	Central Data Handling Facility
CNES	Centre National D'Etudes Spatiales/France
COSTR	Collaborative Solar Terrestrial Research Initiative
CSP	Cross Support Access Point
DLR	Deutsche Forschungs-u. Versuchsanstalt fuer Luft und Raumfahrt e.V./Germany
DOC-CRC	Department of Communications, Communications Research Centre/Canada
DSN	Deep Space Network
ESA	European Space Agency/Europe
ESOC	European Space Operations Center
GCF	Ground Communications Facility
GSFC	Goddard Space Flight Center
GSOC	German Space Operations Center
ICD	Interface Control Document
IM	Information Management
INPE	Instituto de Pesquisas Espaciais/Brazil
ISAS	Institute for Space Astronautics and Science/Japan
ISRO	Indian Space Research Organization/India
ISTP	International Solar-Terrestrial Physics Program
JPL	Jet Propulsion Laboratory
MOA	Memorandum of Agreement
MOS	Marine Observation Satellite
MOU	Memorandum of Understanding
MCSP	Management Cross Support Point
NASA	National Aeronautics and Space Administration/USA
NASCOM	NASA Communications Network
NASDA	National Space Development Agency of Japan/Japan
NM	Network Management
NSSDC	National Space Science Data Center
P	Provider (Agency)

ACRONYMS (continued)

P/MM	Project/Mission Management
RF	Radio Frequency
SFDU	Standard Formatted Data Unit
SIRD	Support Instrumentation Requirements Document
SPOT1	System pou l'Observation de la Terre
SSF	Space Station Freedom
STSP	Solar Terrestrial Science Programme
TOPEX	Topography Experiment
TT&C	Tracking, Telemetry and Control
U	User (Agency)